PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in Temperature Responsive Instruments

We, THE FOXBORO COMPANY, a Corporation organized and existing under and by virtue of the laws of the Commonwealth of Massachusetts, United States of America, of Neponset Avenue, Foxboro, Massachusetts, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to temperature responsive instruments of the type used for recording or indicating, or for control purposes.

It is particularly concerned with such instruments wherein temperatures are represented in the instruments in terms of electrical units, for example, volts.

A practice has been to set up a standard voltage within the instrument for automatic comparison with a voltage representative of temperature. The result of this comparison represents the departure, if any, of the temperature from a reference point represented by the standard voltage.

An object of the present invention is to provide improved comparison apparatus.

According to the invention an instrument responsive to variable temperature includes a first thermocouple unit for producing an electrical potential varying with temperature, a potential comparison circuit, including a standard cell or like source of fixed potential, providing a reference potential for comparison with the first-mentioned potential, and a second thermocouple unit arranged to be located in a temperature ambiency to which the first thermocouple unit is responsive at least in part, for varying the reference potential in compensation for non-linearity between the potential of the first thermocouple unit and the temperature to which it is responsive, at least part of the potential of the second thermocouple unit being applied to the standard cell in a totalling action with respect to the potential of the standard cell or the like. Where the temperature to be measured is the difference between two temperatures, a third thermocouple, arranged to be located in a temperature ambiency different from the said first-mentioned temperature ambiency, is connected to the first thermocouple to produce a differential potential for comparison with the reference potential.

Where the source of fixed potential is a standard cell, a voltage divider may be interposed between the second thermocouple and the standard cell so that the voltage due to the second thermocouple is reduced before being applied to the standard cell.

Advantageously the potential comparison is continuously effected during the operation of the instrument and the result recorded. The instrument may then be provided with a balancing device which automatically counteracts a difference between the reference potential and the potential with which the reference potential is compared while the recording instrument is responding to such difference. This balancing device may comprise two current responsive motor devices selectively operable according to whether the reference potential is greater or less than the potential with which it is compared. The motor devices may actuate a balancing capacitor.

On example of the invention will be described with reference to the accompanying drawing, which shows a schematic diagram of a recording instrument.

The device as represented in the drawing is only a vehicle for illustration of the invention, and is an instrument for recording the values of a variable temperature differential condition. At the left of the drawing there are two temperature chambers 10 and 11. The instrument records the difference in temperatures of these chambers, that is, the temperature differential.

In each temperature chamber there is a thermocouple as a temperature sensing element, as at 12 and 13. These thermo-

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couples respond to temperature by producing small voltages representative of the temperature.

The temperature differential of the thermocouples 12 and 13 produces a representative voltage differential by bucking the voltages produced by the thermocouples against each other. This bucking is accomplished by connecting thermocouple legs of like polarity, by a connecting line 14. The differential voltage thus produced is representative of the temperature difference between the chambers 10 and 11.

This differential voltage is applied, through a line filter 15, to a measuring circuit 16, for comparison with the voltage of a standard cell 17 which is associated with the measuring circuit 16. A measuring circuit of this type, and such a comparison of voltages, is disclosed in the Specifications of British Patents Nos. 655359 and 656074.

Referring again to the drawing of the present application, the measuring circuit 16 and its associated arrangements constitute a form of the well-known null balance circuit, in which the result of the standard cell comparison, that is, the unbalance of the measuring circuit 16, is amplified in the voltage unbalance amplifier 18. The direction of the unbalance is determined in the unbalance detector portion of the unit 19, and the unbalance is then amplified in the power amplifier portion of the unit 19 and thereafter applied to one of the solenoid coils 20 and 21, depending upon the direction of unbalance.

Above the solenoid coils 20 and 21 there is shown a balanding capacitor 22 which is mechanically connected to the solenoid plungers 23 and 24 and yet is electrically a part of the measuring circuit 16, through leads 25 and 26. Thus, unbalance applied to one of the coils 20 and 21 results in automatic mechanical adjustment of the variable capacitor 22 until the measuring circuit 16 is balanced. The adjustment of the capacitor 22 is therefore a function of the temperature differential between the chambers 10 and 11.

A record of this temperature differential is made by mechanically connecting a pen 27 and chart 28, as a recording arrangement, to the moving portion of the balancing capacitor 22, through a suitable linkage 29. A power source, 60 cycle for example, supplies the entire circuit through the voltage unbalance amplifier 18.

This instrument, as thus far described, customarily measures equal millivolt increments rather than equal temperature increments. The temperature-millivolt curve is not linear. The voltage produced by a given differential temperature span at one section of the temperature range is different from the voltage produced by the same differential temperature span at another section of the temperature range. Thus there are produced 2.96 millivolts by an iron constantan thermocouple when its temperature is increased from 100° F. to 200° F. The same thermocouple produces 3.52 millivolts when its temperature is increased from 1500° F. to 1600° F.

The circuit and arrangement with which this invention is particularly concerned, as will be shown, is in addition to the circuit and arrangement already described herein, and provides correction for the temperature-millivolt curve so that a differential temperature span at one temperature range section will produce, in close approximation, the same millivoltage as the same differential span at another range section.

This result is produced by applying an automatically variable corrective voltage to the circuit in series with standard cell 17 so that the value of the corrective voltage is totalled with that of the cell 17. This voltage is produced by placing a third thermocouple 30 in one of the temperature chambers. In this instance the thermocouple 30 is located in chamber 11 in the same temperature ambiency as that of the thermocouple 13. The thermocouple 30 is thus exposed to a temperature which is close enough to the temperature being measured to satisfy practical purposes in providing a corrective voltage to be totalled with the voltage of the standard cell 17. A voltage divider is associated with the corrective thermocouple 30, as at 31, so that the corrective voltage applied to the standard cell 17 is in reduced proportion to the voltage produced by the second thermocouple 13.

As the temperature range section of chambers 10 and 11 is changed, for example, from about 100° F. to about 1500° F., the voltage of the thermocouple 30, as reduced by the voltage divider 31, is automatically totalled with the voltage of the standard cell 17, thus providing an automatic correction of the voltage of the standard cell. However, the number of millivolts generated as a differential from the thermocouples 12 and 13, for the same temperature differential, is also changed. This means that the recording range of the instrument is changed, that is, the number of millivolts necessary to cause the pen to go from 0% to 100% of scale of the chart is changed. The net result is that the instrument records, in close approximation, the same temperature difference at the 1500° F. range as at the 100° F. range.

The corrective voltage from the thermocouple 30 may be added to or subtracted from the standard cell 17, according to the circumstances of the temperature change. Therefore the voltage from the thermocouple 30 may be said to be totalled with the voltage of the standard cell 17.

In the particular embodiment shown in the

drawing, the variable condition may be considered to be the voltage differential representing the temperature differential, and the voltage from the thermocouple 30 may be considered to be a variable condition operatively associated with the voltage differential variable condition. In modifications within the scope of this invention, the voltage from either of the thermocouples 12 and 13 may be considered a variable condition operatively associated with the voltage differential variable condition, within the meaning of the phrase "operatively associated."

If desired, a single thermocouple instrument may be similarly corrected in its standard cell voltage by a corrective thermocouple voltage applied to the standard cell through a voltage divider.

Many other possible embodiments of the present invention may be made without departing from the scope thereof, and it is to be understood that the embodiment hereinbefore described and shown in the accompanying drawing is merely illustrative.

What we claim is:—

1. An instrument responsive to variable temperature including a first thermocouple unit for producing an electrical potential varying with temperature, a potential comparison circuit, including a standard cell or like source of fixed potential, providing a reference potential for comparison with the first-mentioned potential, and a second thermocouple unit, arranged to be located in a temperature ambiency to which the first thermocouple unit is responsive at least in part, for varying the reference potential in compensation for non-linearity between the potential of the first thermocouple unit and the temperature to which it is responsive, at least part of the potential of the second thermocouple unit being applied to the standard cell in a totalling action with respect to the potential of the standard cell or the like.

2. An instrument according to claim 1, provided with a third thermocouple arranged to be located in a temperature ambiency different from the said first-mentioned temperature ambiency, the first and third thermocouples being connected to produce a differential potential for comparison with the reference potential.

3. An instrument according to claim 1 or claim 2, in which the source of fixed potential is a standard cell and a voltage divider is interposed between the second thermocouple and the standard cell so that the voltage due to the second thermocouple is reduced before being applied to the standard cell.

4. An instrument according to any one of the preceding claims, in which the potential comparison is continuously effected during the operation of the instrument and the result recorded.

5. An instrument according to claim 4, provided with a balancing device which automatically counteracts a difference between the reference potential and the potential with which the reference potential is compared while the recording instrument is responding to such difference.

6. An instrument according to claim 5, in which the balancing device comprises two current responsive motor devices selectively operable according to whether the reference potential is greater or less than the potential with which it is compared.

7. An instrument according to claim 8, in which the motor devices actuate a balancing capacitor.

8. An instrument responsive to variable temperature substantially as hereinbefore described with reference to the accompanying drawing.

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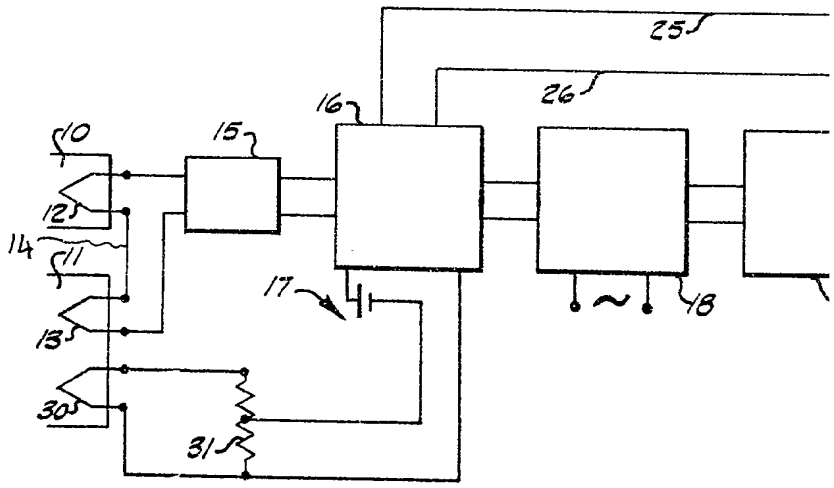
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702,510 COMPLETE SPECIFICATION
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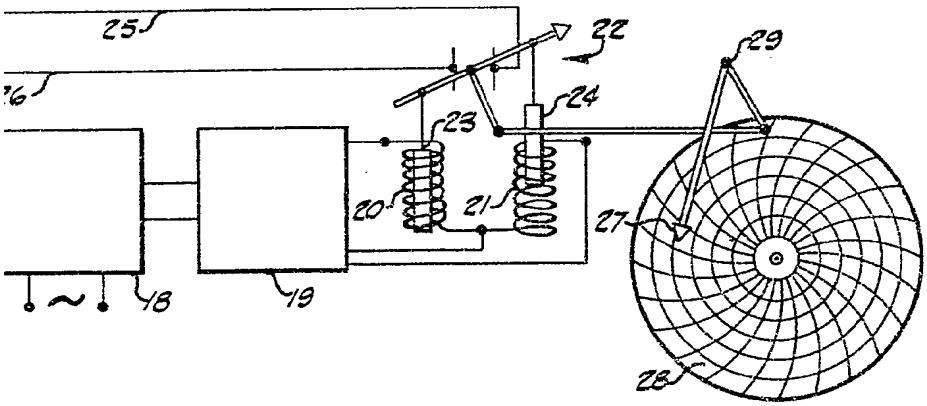

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